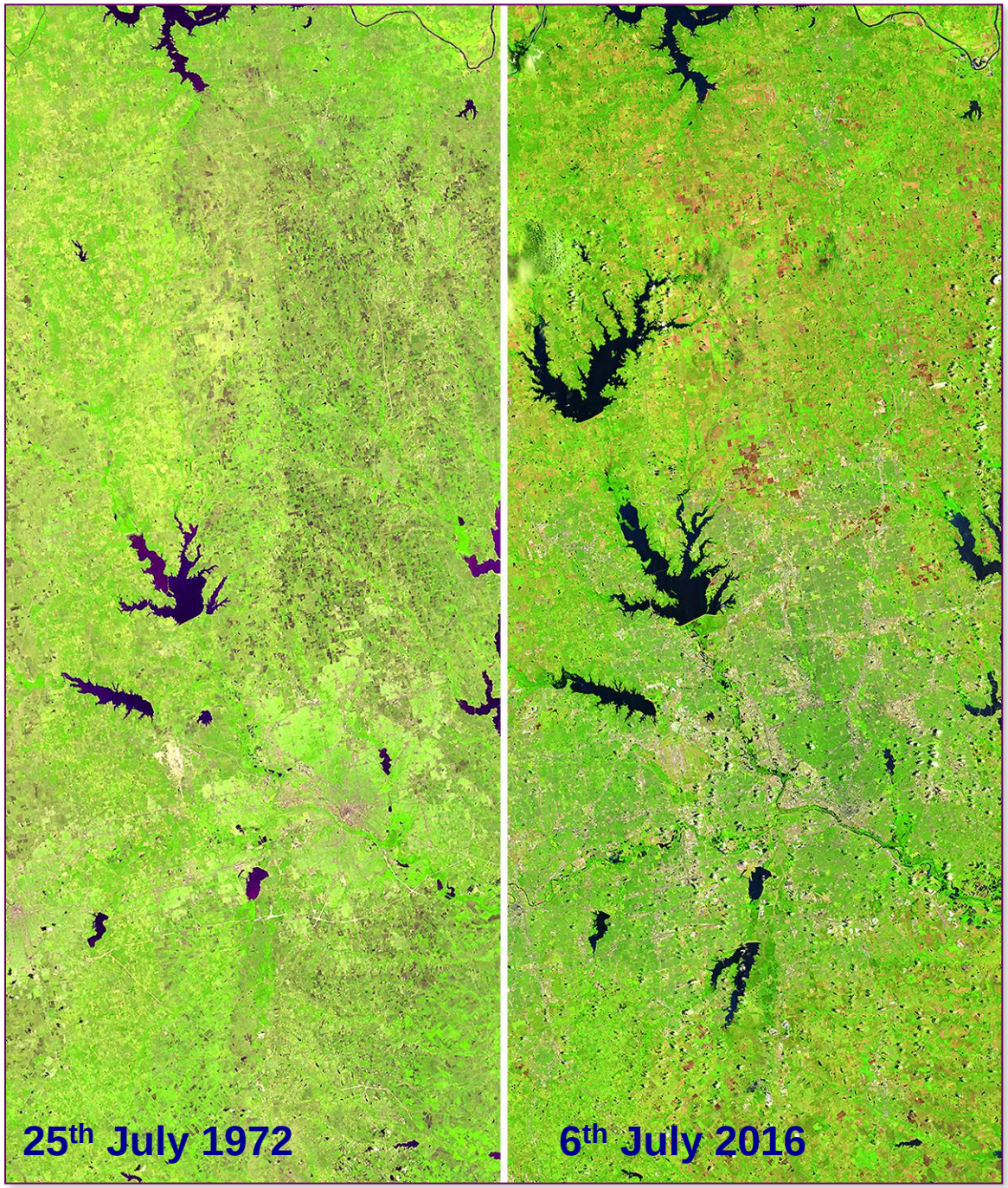
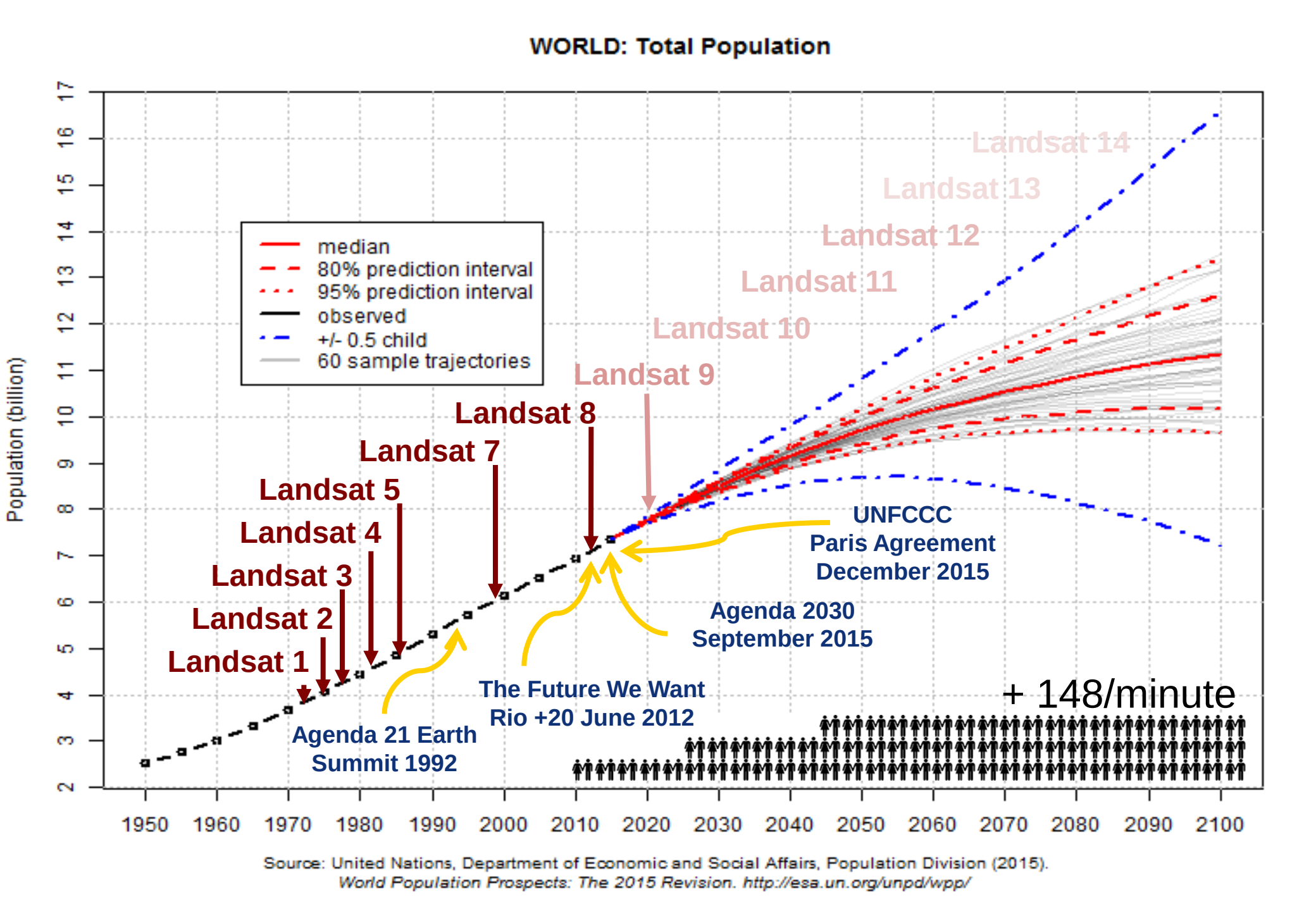


The importance of the Landsat Global Archive Consolidation for the production of the next generation of terrestrial Essential Climate Variables

A. Belward, J-F. Pekel, A. Cottam, N. Gorelick, M. Wulder, J. White, T. Loveland, C. Woodcock, W. Cohen, G. Fosnight, J. Shaw, J. Masek, D.Roy, C. Richter, S. Briggs, M. Dowell, S. Eggleston. H. Dolman, R. Saunders, M. Verstraete, B. Sloyan, T. Tanhua, K. Steffen, S. Quegan, P. Lecomte, K. Hill, R. Husband, D. Stammer, A. Simmons


WORLD: Total Population
Population (billion)
median
80% prediction interval
95% prediction interval
observed
+/- 0.5 child
60 sample trajectories
Landsat 1
Landsat 2
Landsat 3
Landsat 4
Landsat 5
Landsat 7
Landsat 8
Landsat 9
Landsat 10
Landsat 11
Landsat 12
Landsat 13
Landsat 14
Agenda 21 Earth Summit 1992
The Future We Want Rio +20 June 2012
Agenda 2030 September 2015
UNFCCC Paris Agreement December 2015
+ 148/minute
Source: United Nations, Department of Economic and Social Affairs, Population Division (2015).
World Population Prospects: The 2015 Revision. http://esa.un.org/unpd/wpp/

COP-21: Paris Agreement Article 7 (7c)

- Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision- making

SBSTA Conclusions:

- Invited GCOS to collaborate with relevant partners to continue enhancing access to, and understanding and interpretation of, data products and information to support decision-making on adaptation and mitigation at national, regional and global scales

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM
@
PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

REPORT ON THE ADEQUACY OF THE GLOBAL CLIMATE OBSERVING SYSTEMS

United Nations Framework Convention on Climate Change

November 2 - 13, 1998
Buenos Aires, Argentina

October 1998
GCOS-48

GLOBAL CLIMATE OBSERVING SYSTEM

WMO of UNESCO UNEP ICSU

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

THE SECOND REPORT ON THE ADEQUACY OF THE GLOBAL OBSERVING SYSTEMS FOR CLIMATE IN SUPPORT OF THE UNFCCC

April 2003

GCOS – 82

GLOBAL CLIMATE OBSERVING SYSTEM

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE GLOBAL OBSERVING SYSTEM FOR CLIMATE IN SUPPORT OF THE UNFCCC

October 2004

GCOS - 92

(WMO/TD No. 1219)

UNITED NATIONS ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL FOR SCIENCE

GLOBAL CLIMATE OBSERVING SYSTEM

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED PRODUCTS FOR CLIMATE

Supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC"

September 2006

GCOS – 107

INTERNATIONAL COUNCIL FOR SCIENCE

GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

WMO IOC UNEP ICSU

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE GLOBAL OBSERVING SYSTEM FOR CLIMATE IN SUPPORT OF THE UNFCCC

(2010 UPDATE)

August 2010

GCOS-138

(GOOS-184, GTOS-76, WMO-TD/No. 1523)

UNITED NATIONS ENVIRONMENT PROGRAMME

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GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

SYSTEMATIC OBSERVATION REQUIREMENTS FOR SATELLITE-BASED DATA PRODUCTS FOR CLIMATE

2011 Update

Supplemental details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)"

December 2011

GCOS – 154

UNITED NATIONS ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL FOR SCIENCE

GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

http://gcos.wmo.int

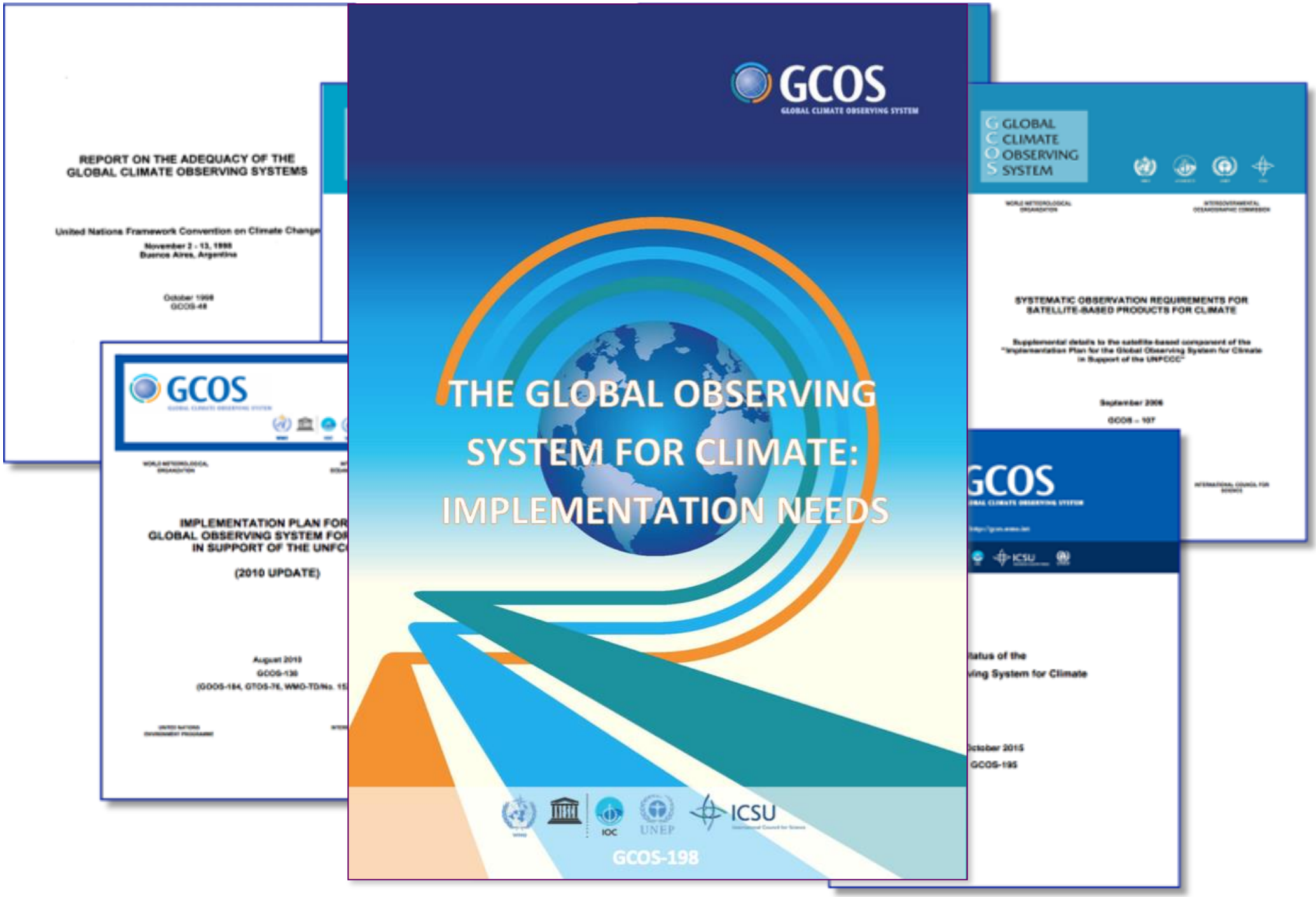
WMO IOC ICSU UNEP

Status of the

Global Observing System for Climate

October 2015

GCOS-195


REPORT ON THE ADEQUACY OF THE
GLOBAL CLIMATE OBSERVING SYSTEMS
United Nations Framework Convention on Climate Change
November 2 - 13, 1998
Buenos Aires, Argentina
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GCOS-48
GCOS
IMPLEMENTATION PLAN FOR
GLOBAL OBSERVING SYSTEM FOR
IN SUPPORT OF THE UNFC
(2010 UPDATE)
August 2010
GCOS-138
GCOS
GLOBAL CLIMATE OBSERVING SYSTEM
THE GLOBAL OBSERVING
SYSTEM FOR CLIMATE:
IMPLEMENTATION NEEDS
IOC
UNEP
ICSU
GCOS-198
GLOBAL
CLIMATE
OBSERVING
SYSTEM
SYSTEMATIC OBSERVATION REQUIREMENTS FOR
SATELLITE-BASED PRODUCTS FOR CLIMATE
Supplemental details to the satellite-based component of the
"Implementation Plan for the Global Observing System for Climate
in Support of the UNFCCC"
September 2006
GCOS – 107
GCOS
ICSU
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ving System for Climate
October 2015
GCOS-195

in review

Measurement Domain	Essential Climate Variables
Atmospheric	Surface: Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. Upper-air: Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget, Lightning. Composition: Carbon Dioxide, Methane, Other long-lived greenhouse gases, Ozone, Aerosol, Precursors for aerosol and ozone.
Oceanic	Physics: Temperature, Sea Surface Temperature, Salinity, Sea Surface Salinity, Currents, Surface Currents, Sea Level, Sea State, Sea Ice, Ocean Surface Stress Biogeochemistry: Inorganic Carbon, Oxygen, Nutrients, Transient Tracers, Nitrous Oxide, Ocean Colour Biology/Ecosystems: Plankton, Marine Habitat
Terrestrial	Hydrology: River discharge, Groundwater, Lakes, Soil Moisture Cryosphere: Snow, Glaciers, Ice sheets and Ice shelves, Permafrost Biosphere: Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Above-ground biomass, Soil carbon, Fire, Land Surface Temperature Human resource use: Water use, GHG fluxes

Global Glacier Inventory

Glacier Area Changes

Lake Ice Cover

Seasonal Snow Cover Extent

Land Surface Temperature

Lake Surface Temperature

Land Cover Change

Burnt Area

Land Cover

Fire Disturbance

LAI

Lake Area

Lake Colour

Lake Development (permafrost)

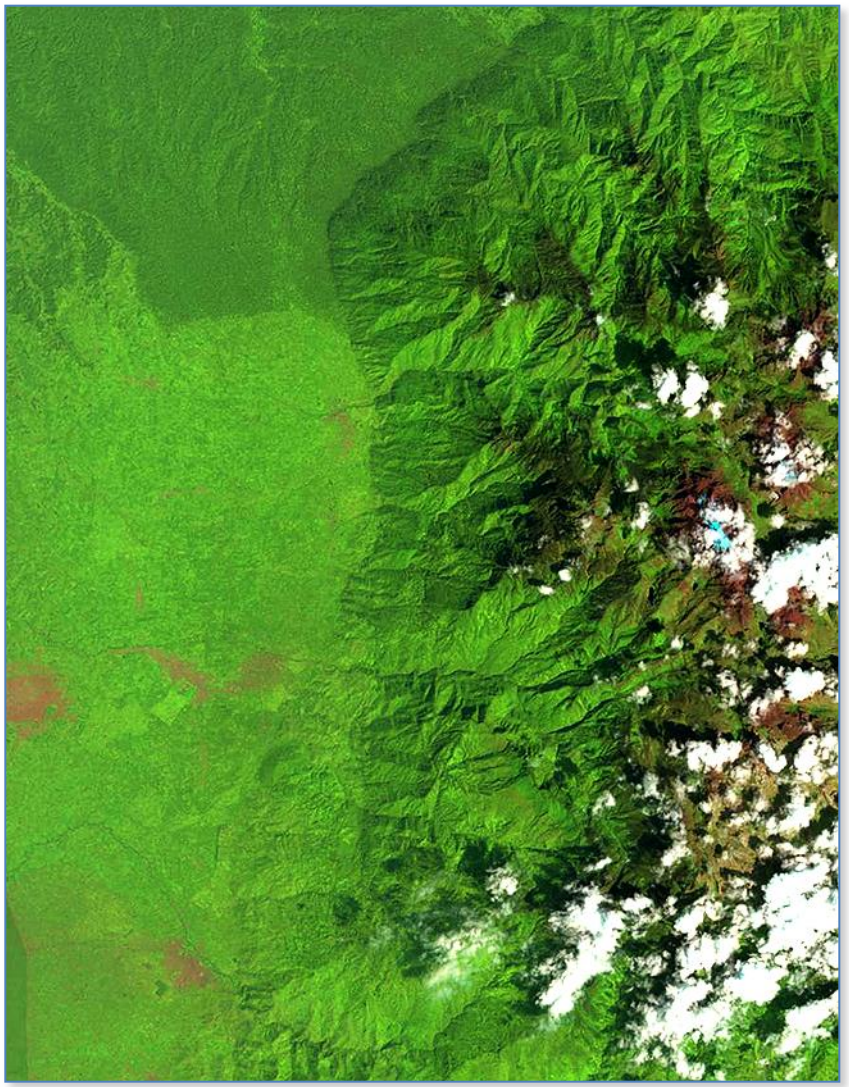
Surface Inundation (soil moisture)

Bare Soil Cover

Albedo

FAPAR

Peatland Area (Soil Carbon)



P173 R60 8th January 2015 USGS/NASA

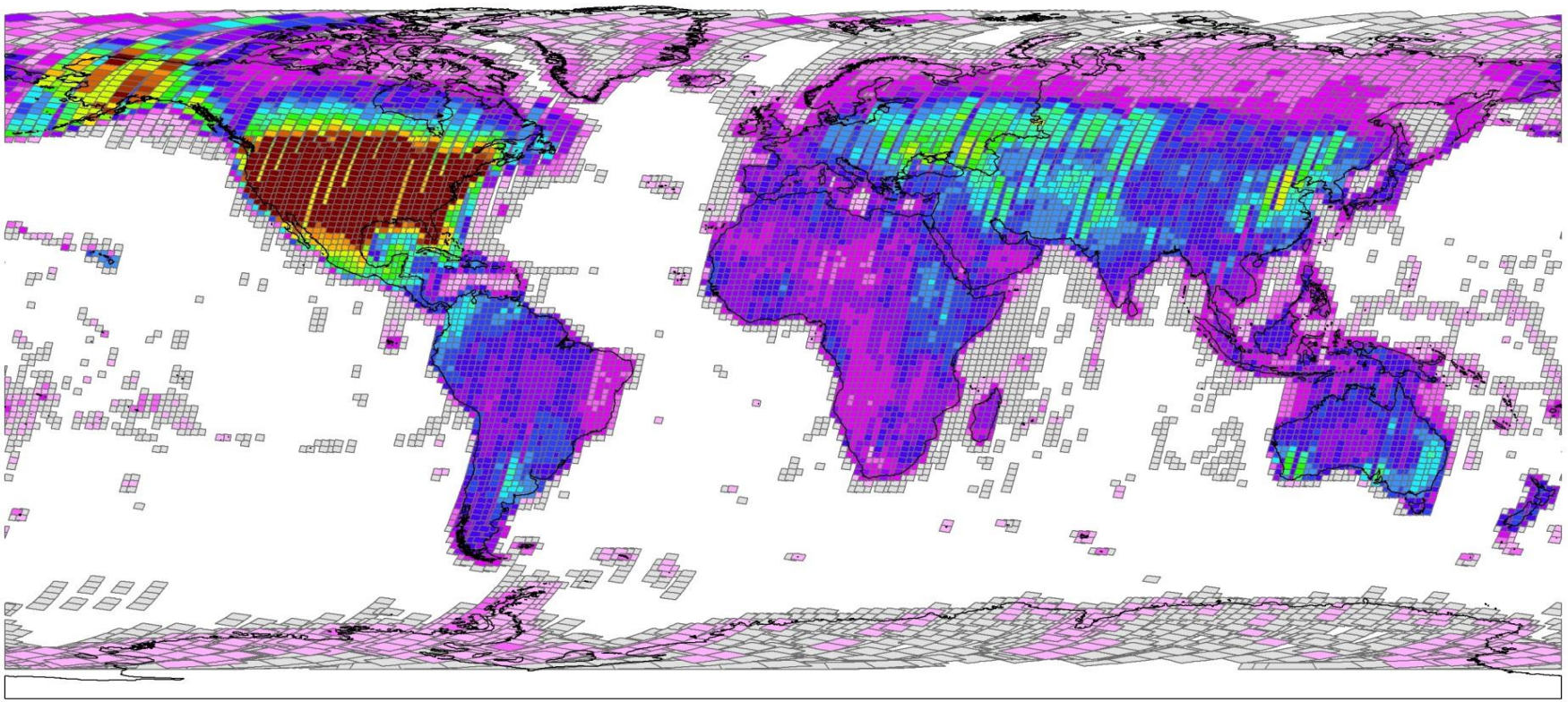
Table of Contents

2.3 Data management, stewardship and access

2.4 Production of Integrated ECV Products

USGS archive prior to LGAC

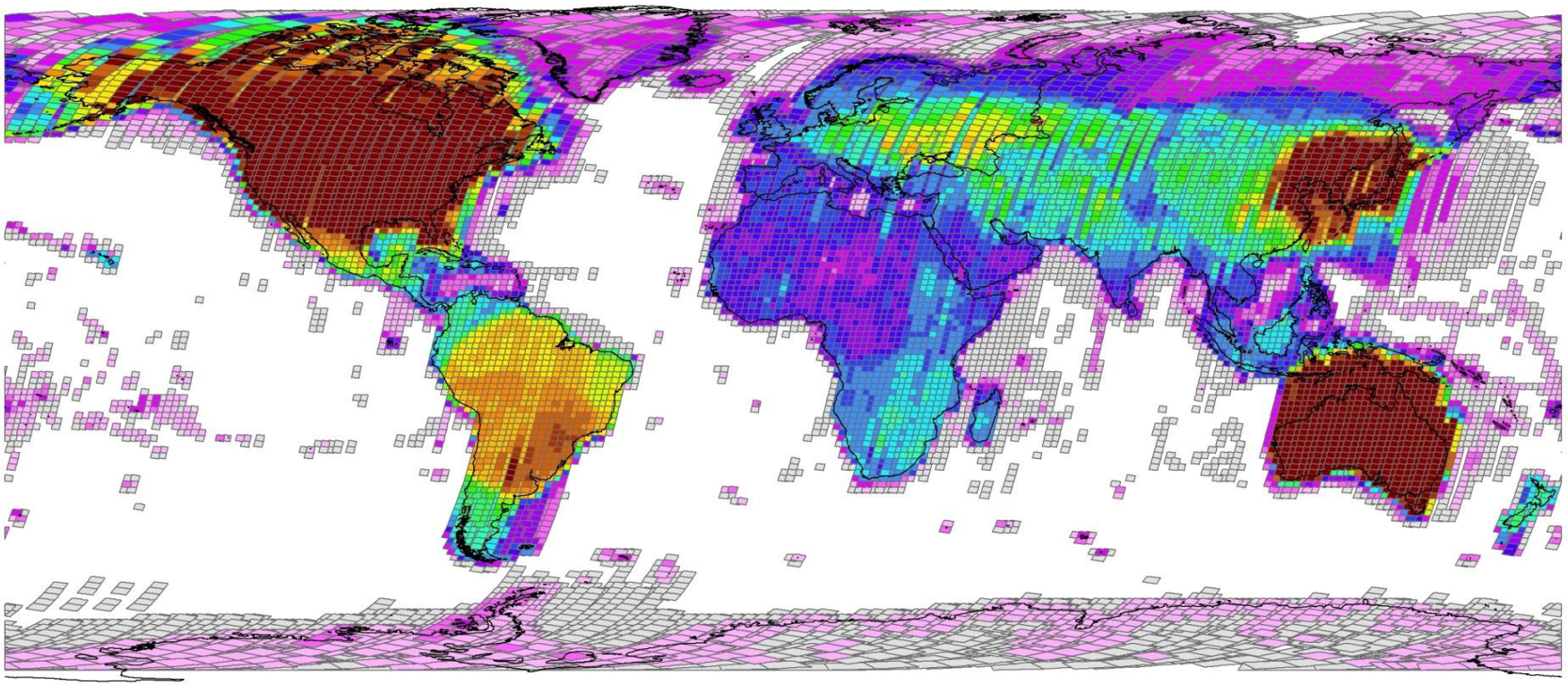
c.a. 2.6 million images



Wulder, et al. 2016. RSE. http://dx.doi.org/10.1016/j.rse.2015.11.032

USGS archive up to Jan 1, 2015

c.a. 5.8 million images... 3.2 million images added by LGAC



Number of images

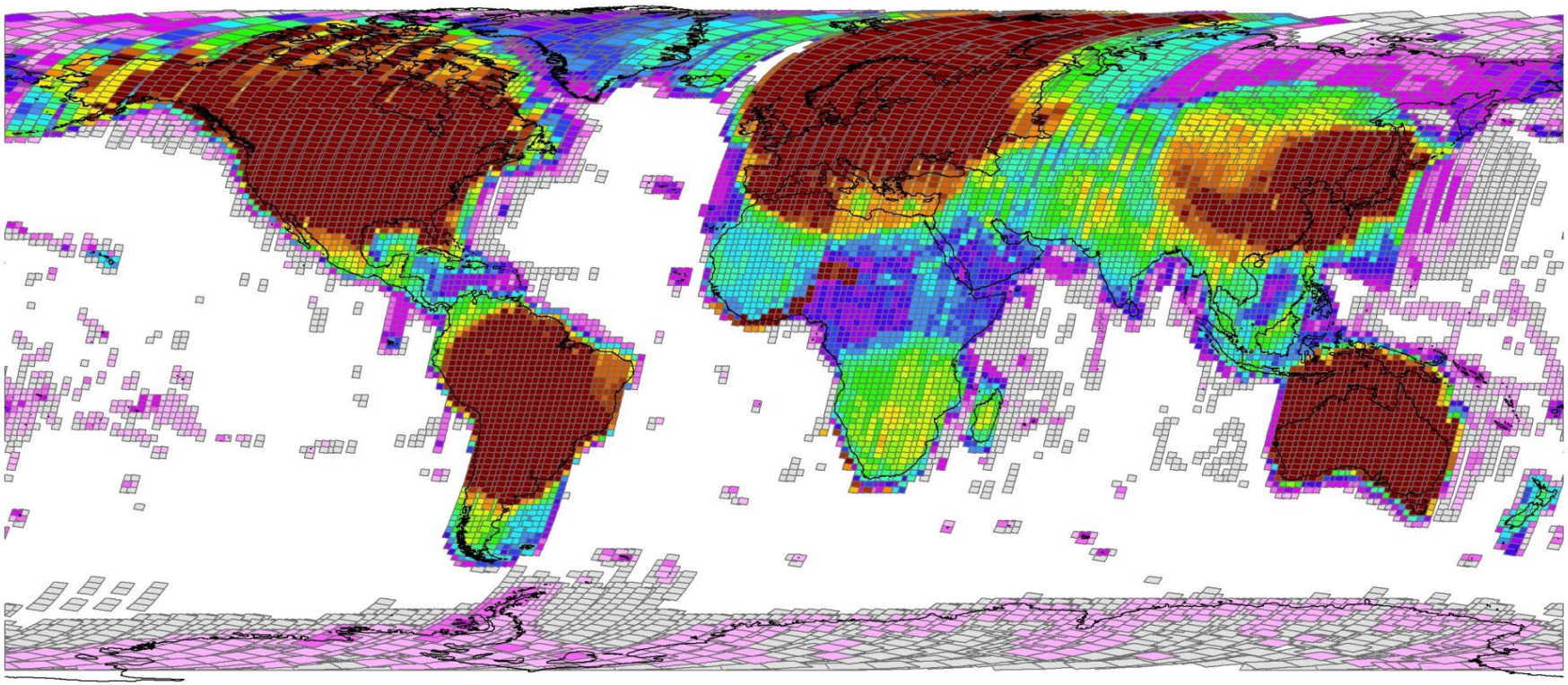
1-50	200-250	400-450	600-650	800-850
50-100	250-300	450-500	650-700	850-900
100-150	300-350	500-550	700-750	900-950
150-200	350-400	550-600	750-800	>950

Archive holdings as of January 1, 2015

Wulder, et al. 2016. RSE. http://dx.doi.org/10.1016/j.rse.2015.11.032

Future archive

an additional ~ 2.3 million images



Number of images

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50-100	250-300	450-500	650-700	850-900
100-150	300-350	500-550	700-750	900-950
150-200	350-400	550-600	750-800	>950

Potential future archive holdings (with LGAC)

Wulder, et al. 2016. RSE. http://dx.doi.org/10.1016/j.rse.2015.11.032

Box 4 Global Climate Observing System climate monitoring principles

(Revised Reporting Guidelines as agreed by the UNFCCC at Bali, December 2007, decision 11/CP.13)

Effective monitoring systems for climate should adhere to the following principles:

a) The impact of new systems or changes to existing systems should be assessed prior to implementation;
b) A suitable period of overlap for new and old observing systems is required;
c) The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves;
d) The quality and homogeneity of data should be regularly assessed as a part of routine operations;
e) Consideration of the needs for environmental and climate-monitoring products and assessments, such as Intergovernmental Panel on Climate Change assessments, should be integrated into national, regional and global observing priorities;
f) Operation of historically-uninterrupted stations and observing systems should be maintained;
g) High priority for additional observations should be focused on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution;
h) Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation;
i) The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted;
j) Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

UNFCCC CoP decision 11/CP.13

Furthermore, operators of satellite systems for monitoring climate need to:

a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system;

b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.

Thus satellite systems for climate monitoring should adhere to the following specific principles:

a) Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained;

b) A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations;

c) Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured;

d) Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured;

e) On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored;

f) Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate;

g) Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained;

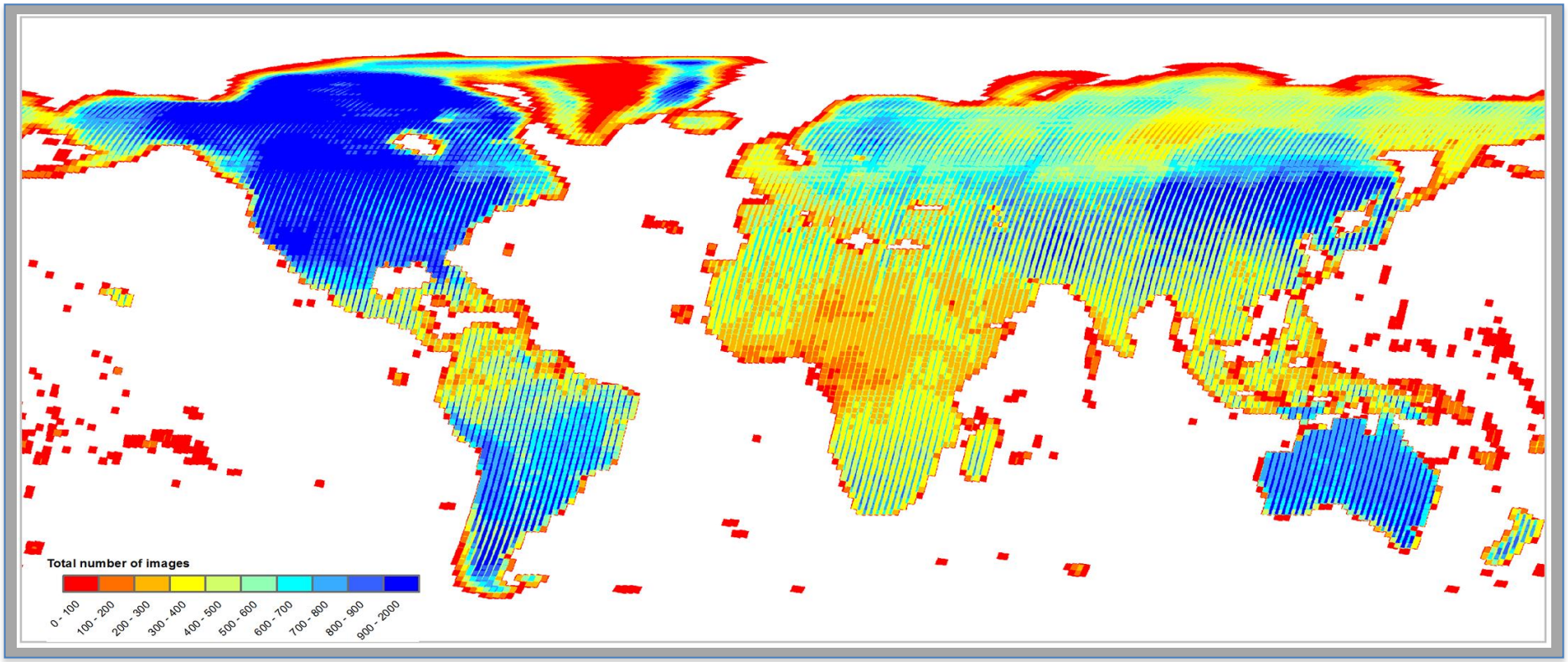
h) Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on decommissioned satellites;

i) Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation;

Random errors and time-dependent biases in satellite observations and derived products should be identified.

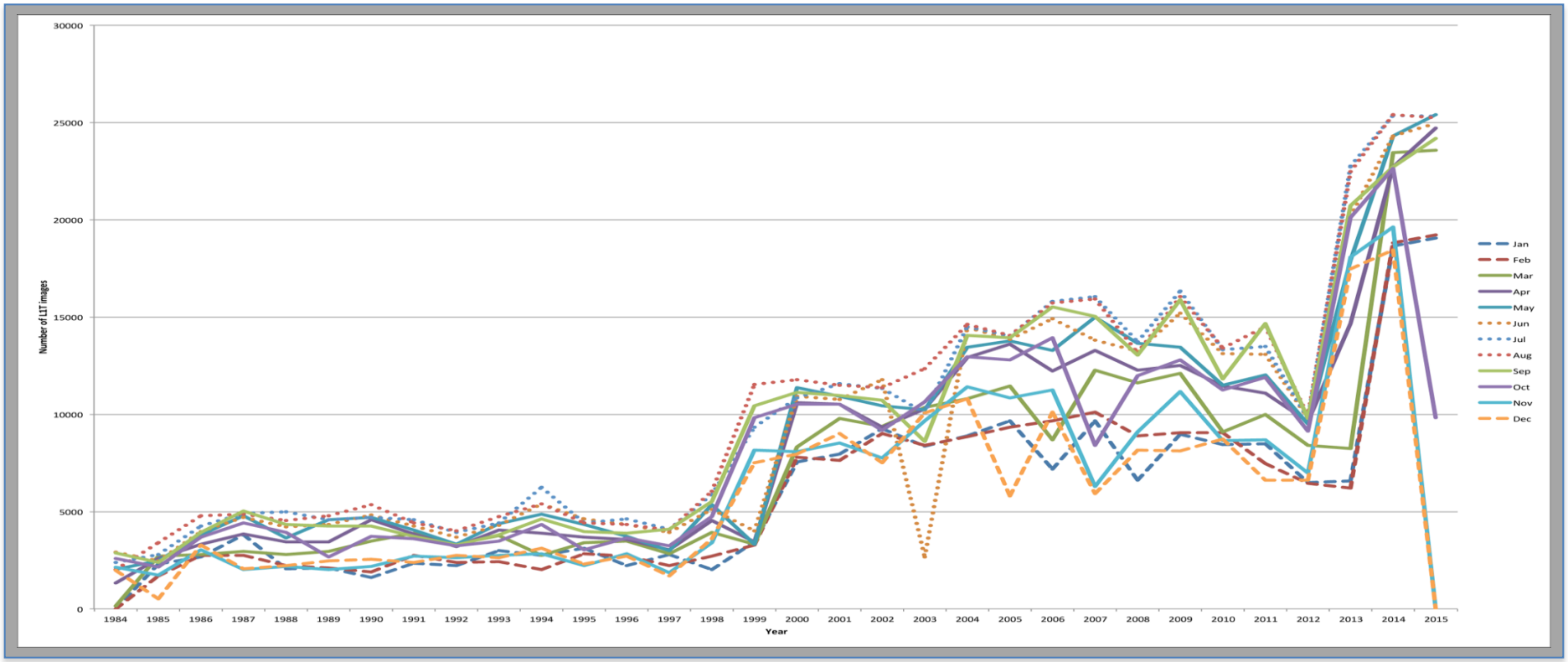
UNFCCC CoP decision 11/CP.13

Source JRC and GEE (J-F. Pekel, A. Cottam, N. Gorelick, A.S. Belward)



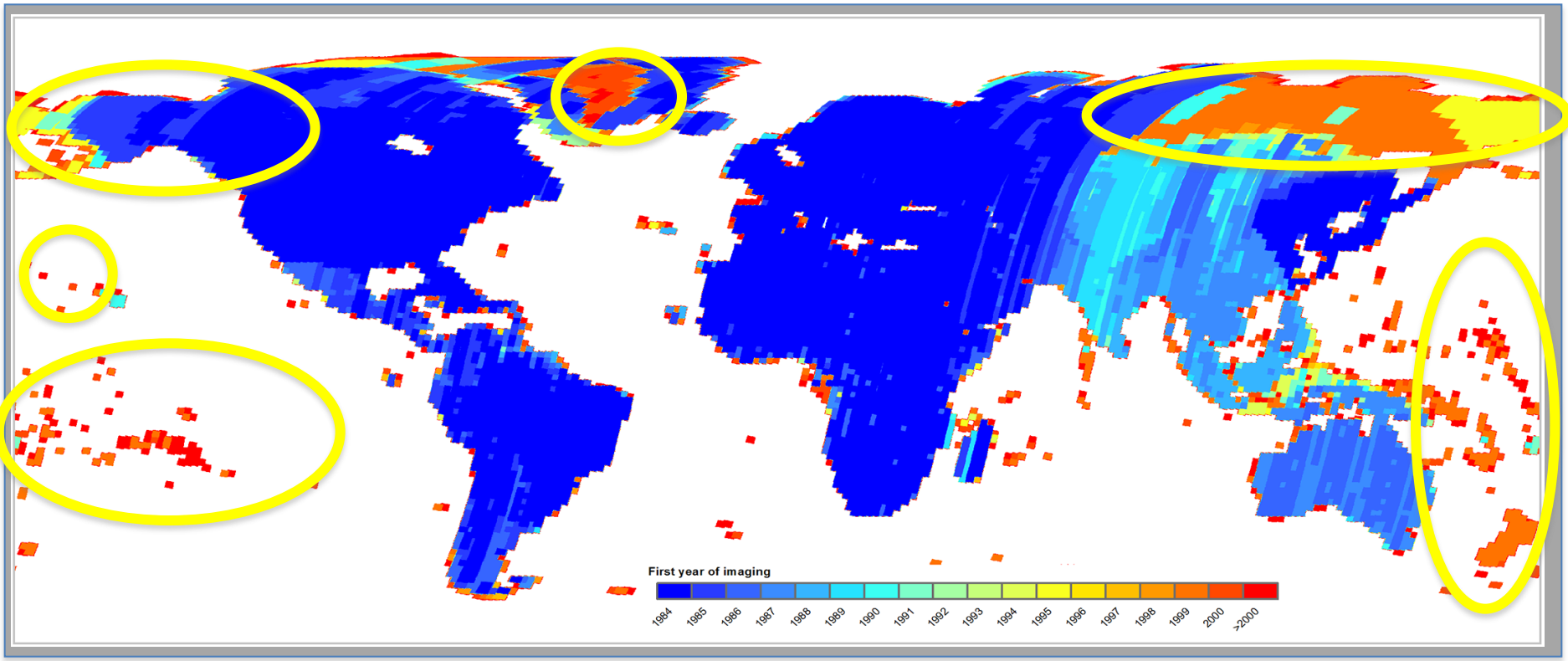
Total number of L1T unique views
L5,7,8 March 1984 to October 2015
(min 11, max 1881, mean 537, median 482)

Source JRC and GEE (J-F. Pekel, A. Cottam, N. Gorelick, A.S. Belward)



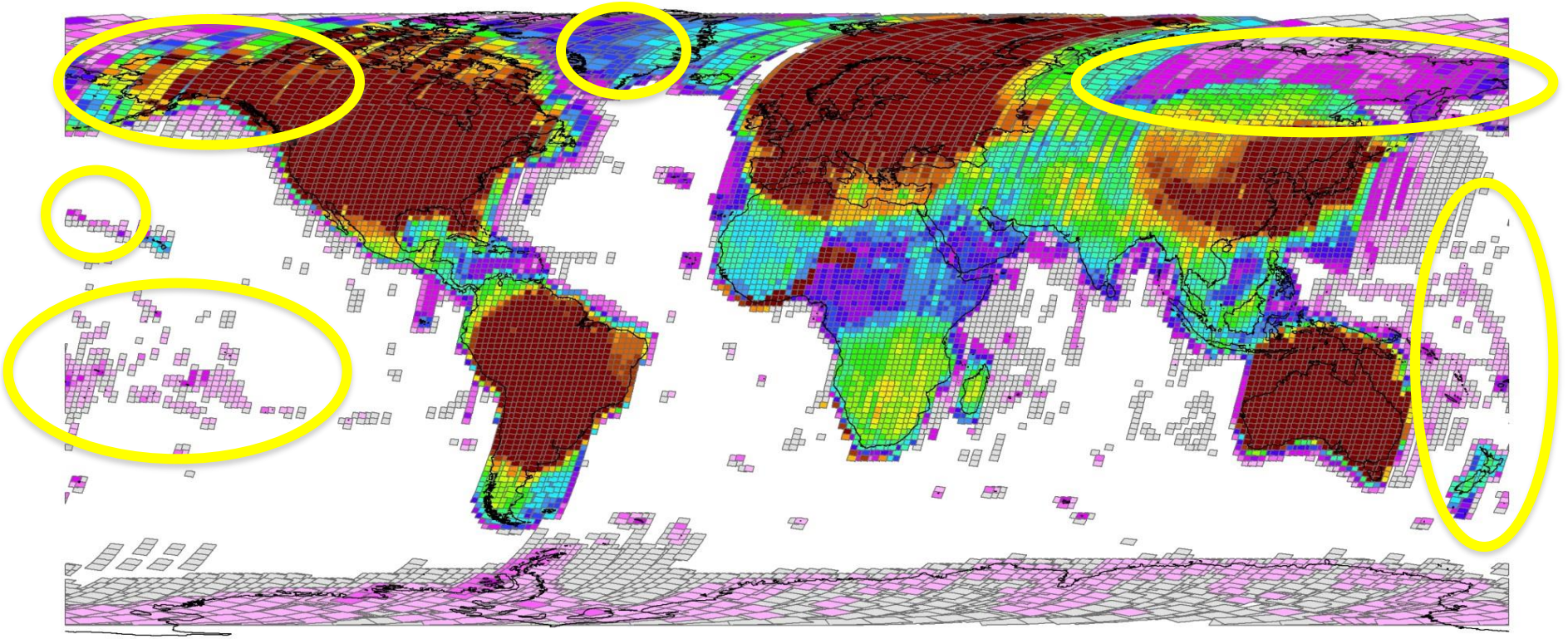
Rate of image acquisition by month L5,7,8 L1T (March 1984 to October 2015)

Source JRC and GEE (J-F. Pekel, A. Cottam, N. Gorelick, A.S. Belward)



First year of imaging L5,7,8 L1T (1984 – 2013)

SPOT (1986), IRS (1988), Resurs (1988) ?



Number of images

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50-100	250-300	450-500	650-700	850-900
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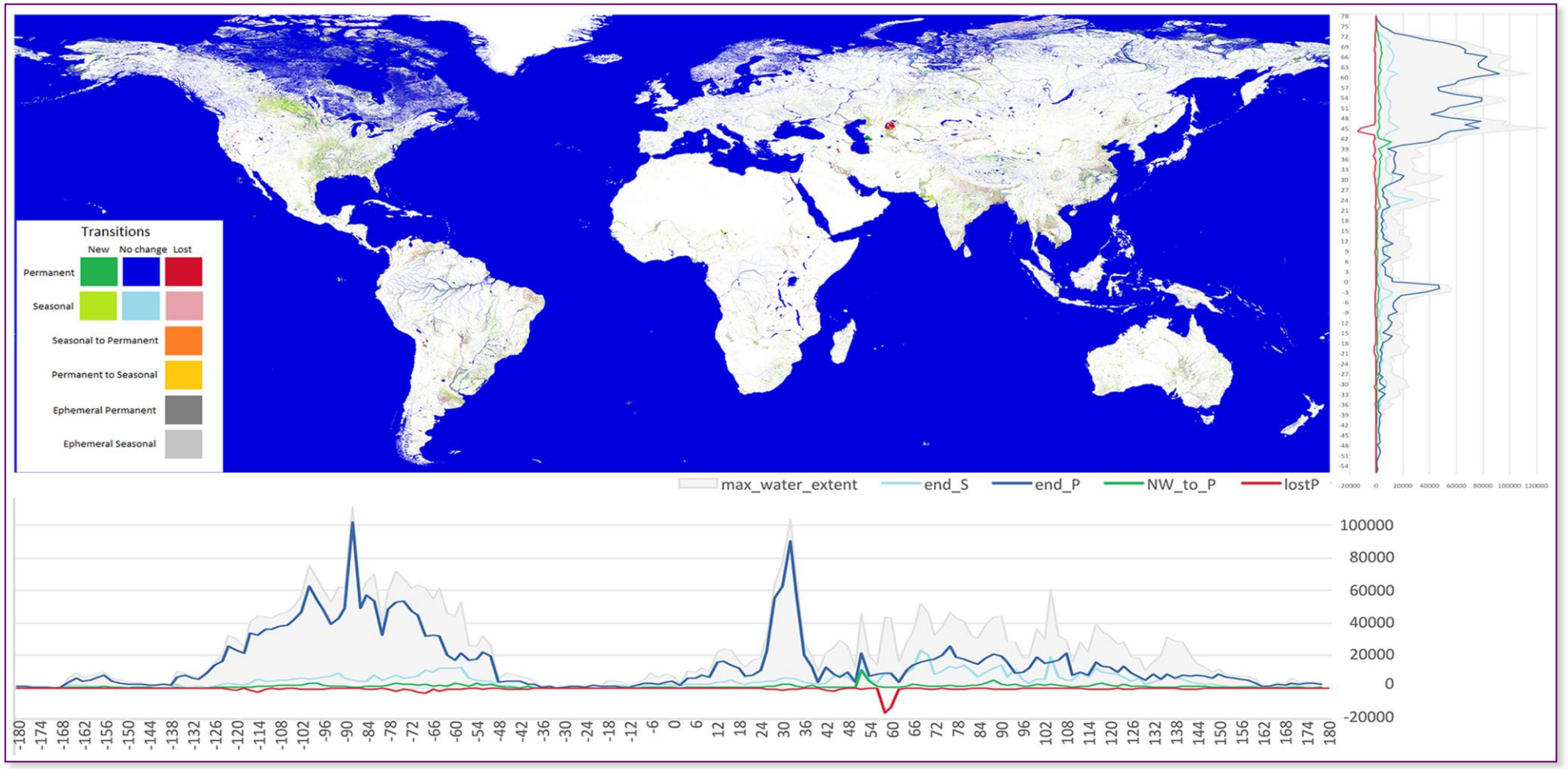
150-200	350-400	550-600	750-800	>950

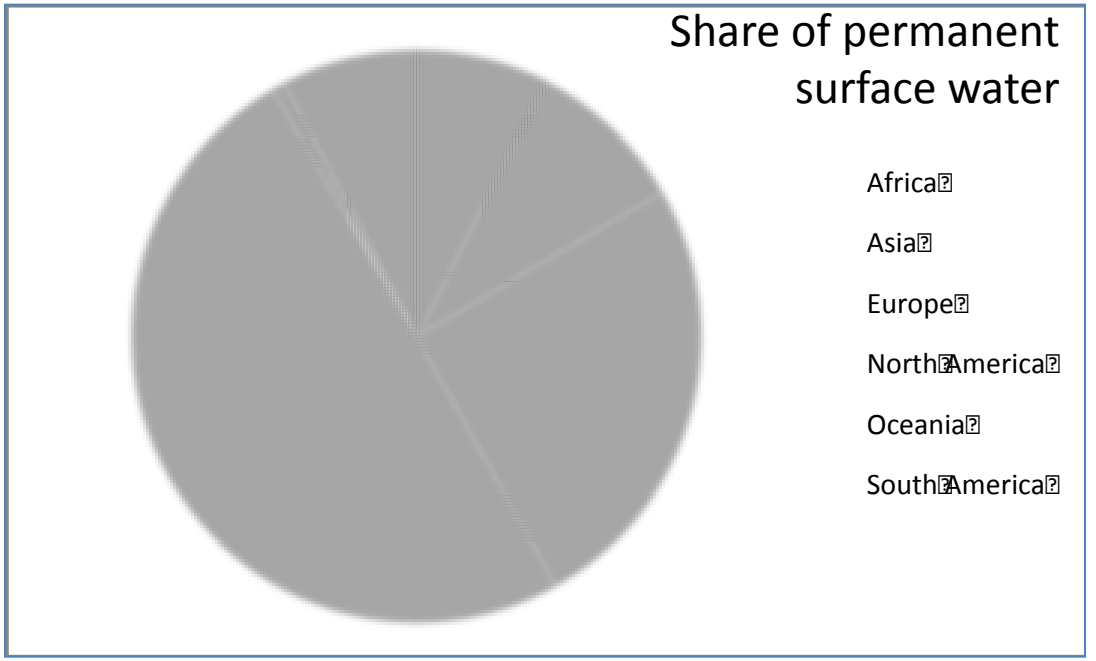
Potential future archive holdings (with LGAC)

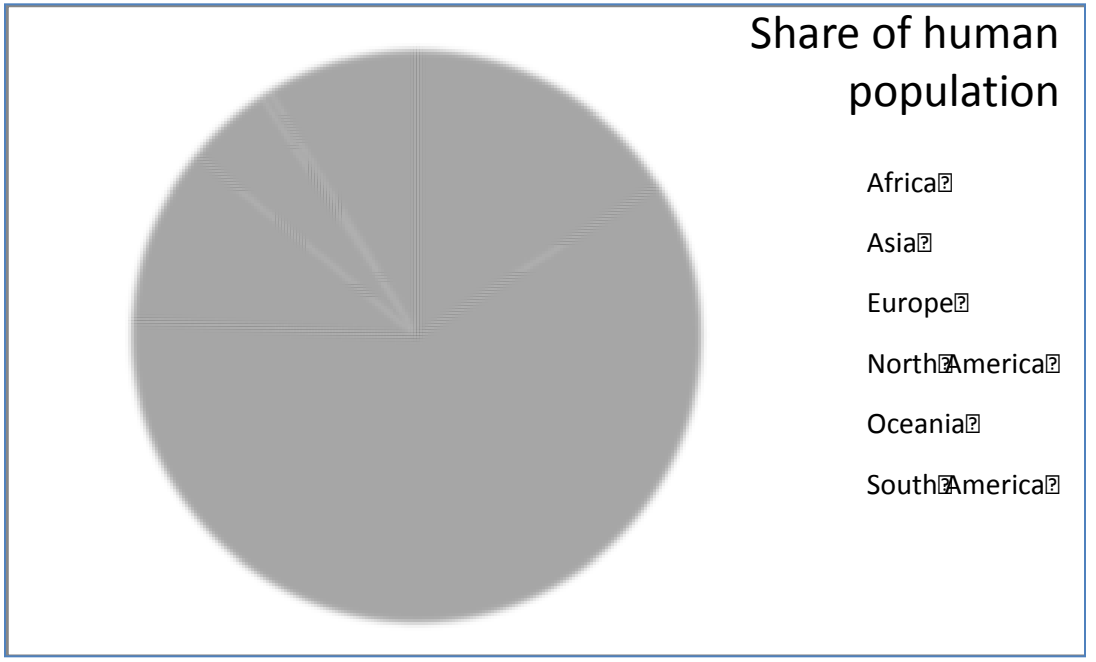
Wulder, et al. 2016. RSE.

Source Global Surface Water Occurrence: JRC/GEE 2016



a 1-degree latitude/longitude summary of surface water area for maximum water extent, seasonal surface water occurrence October 2014 to October 2015, permanent water occurrence October 2014 to October 2015, new permanent water appearing after 1984 and permanent water lost since 1984.





Source Global Surface Water Occurrence: JRC/GEE 2016 and UN Population division

The views expressed in this slide deck are purely those of the presenter and may not in any circumstances be regarded as stating an official position of the European Commission, the LST or GCOS

European Commission

Lessons and key messages

① The growing Landsat archive (and evolving computing power) underpins a whole new suite of variables for international global environmental and development actions

② LGAC is increasing the availability of climate quality observations – in line with the Global Climate Monitoring Principles agreed by UNFCCC (decision 11/CP.13)

③ Important in at least 19 GCOS Implementation Plan actions. Plan is in review 25th July to 5th September 2016 http://www.wmo.int/pages/prog/gcos/

④ LGAC must continue

⑤ L1T production should progress

⑥ Fusion with other archives should be tested to fill critical geographic and temporal gaps

23rd July 1972

11th February 2013